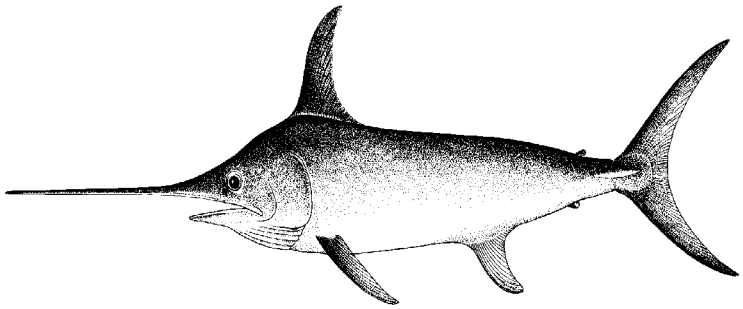
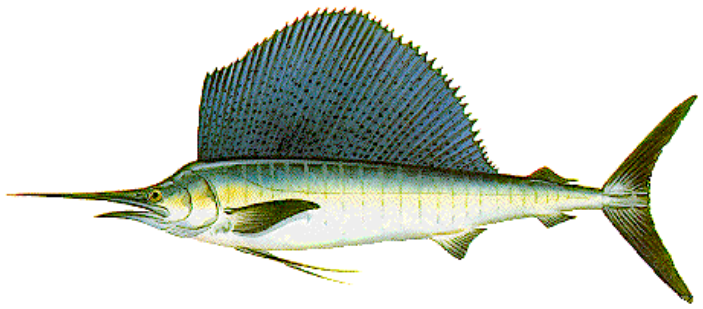


TECHNICAL MEMORANDUM

Using Time and Area Closures to Minimize Incidental Catch and Bycatch in U.S. Atlantic Pelagic Longline Fisheries

National Marine Fisheries Service
Highly Migratory Species Division

October 1999



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Introduction

Pelagic longline gear is the dominant gear used by all fishing nations in the Atlantic Ocean to target swordfish, bigeye tuna, and other highly migratory species. The U.S. pelagic longline fishery is conducted throughout the waters adjacent to the U.S. Atlantic and Gulf of Mexcio coasts, in the Caribbean basin and South Atlantic Ocean targeting swordfish and tunas. The United States fleet is closely monitored and consists of approximately five discrete fishing sectors that use different gear configurations depending on season and homeport. Longline gear can be modified (gear configuration, timing of sets, etc.) to target yellowfin tuna, bigeye tuna, or swordfish. In 1997, 253 pelagic longline vessels reported landing approximately 86,000 swordfish, 71,000 yellowfin tuna, and 22,000 bigeye tuna. Using average prices for these species of $3.94, $2.44, and $2.44 per pound dressed weight, respectively (HMS FMP, 1999), these species alone accounted for $43.7 million in ex-vessel revenues realized by fishermen in 1997. However, pelagic longline gear also catches other species of fish (e.g., marlin, sailfish, and small swordfish under 33 pounds dressed weight), mammals (porpoises or whales that are either caught or entangled), birds, and sea turtles incidental to fishing operations. Many non-target species are discarded for economic or personal reasons, as well as to comply with regulatory mandates. In addition, some of the target species must be released, preferably alive, because of minimum size limits, quotas, or other regulations.

Management of the U.S. pelagic longline fishery in the Atlantic Ocean and associated waters has historically relied upon landing quotas and a minimum size limit for swordfish. Yellowfin tuna and bigeye are also subject to a minimum size, although no quotas are currently in effect for the United States. The incidental catch and bycatch from pelagic longline fisheries has not been regulated directly, but has been a concern for many years because of its impact on the stocks of non-targeted species that include several overfished highly migratory species (HMS), as well as threatened or endangered species. In 1997, the National Marine Fisheries Service (NMFS) began addressing the issue of incidental catch and bycatch discards through the development of the Fishery Management Plan (FMP) for Atlantic tunas, swordfish and sharks and Amendment One to the Atlantic billfish FMP. These documents contained fishery conservation and management measures to address incidental catch and bycatch concerns associated with HMS fisheries, as required by National Standard 9. The Magnuson-Stevens Act defines bycatch as:

> *fish ("fish" means finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds) that are harvested in a fishery, but are not sold or kept for personal use, and includes economic discards and regulatory discards. [Bycatch] does not include fish released alive under a recreational catch and release fishery management program.*

The National Marine Fisheries Service (NMFS) is also subject to other national and international requirements to avoid and reduce incidental catch and bycatch, most notably under the Marine Mammal Protection Act (MMPA), and the Endangered Species Act (ESA). The

MMPA is the principal Federal legislation that guides marine mammal species protection and conservation policy. Under requirements of the MMPA, NMFS produces an annual List of Fisheries that classifies domestic commercial fisheries, by gear type, relative to their rates of incidental mortality or serious injury of marine mammals. Pelagic longline gear has been classified as a Category I fishery, indicating that this gear is associated with frequent serious injury or mortality to marine mammals. The ESA is the primary federal legislation governing interactions between fisheries and species whose continued existence is threatened or endangered. Under the ESA consultative process, NMFS issues a Biological Opinion which outlines expected impacts of the proposed action and specifies terms and conditions which must be met to mitigate impacts on ESA-listed species. Retention of endangered (Kemp's Ridley, Green, Leatherback, and Hawksbill turtles) and threatened (loggerhead turtles) sea turtles is prohibited under the authority of the ESA. Bycatch is minimized through regulatory and non-regulatory implementation of the terms and conditions of the Incidental Take Statement. NMFS utilizes observer data to collect information on sea bird interactions with fishing gear (including pelagic longlines).

The final HMS FMP indicated that time and area closures would become a primary tool to be used to reduce this incidental catch and bycatch in the near term. Simultaneously, additional effort would be placed on research concerning gear modifications and fishing techniques. The HMS FMP included a time/area closure for pelagic longliners aimed at reducing bluefin tuna incidental catch in the mid-Atlantic Bight. Although the draft HMS FMP proposed a time/area closure in the Florida Straits aimed at reducing small swordfish incidental catch, public comment indicated that the closure was likely too small to be effective, and was not comprehensive with respect to the incidental catch of other species.

Goodyear (1998) examined U.S. commercial pelagic longline logbook data to determine the distribution of relative catch rates of billfish and target species by 1, 2, and 5 degree areas and months to identify potential time/area strata that could reduce billfish bycatch. The areas examined were limited to the operational limits of the U.S. pelagic longline fleet, which includes a large area outside the U.S. EEZ. Although the results of Goodyear's study demonstrate that time/area closures could be effective in reducing billfish bycatch in commercial pelagic longline fishing gear, his investigation did not account for redistribution of pelagic longline effort to other open time/area cells. Reallocating commercial pelagic longline efforts could result in similar, or perhaps even higher incidental and bycatch discards of overfished HMS, including billfish and small swordfish. Another point to consider is the spatial distribution of the closed areas, which ranged from the Grand Banks, along the east U.S. coast, Gulf of Mexico and Caribbean. Many of the areas identified by Goodyear are outside the U.S. EEZ where other countries also operate commercial longline fleets. Closure of these areas could disadvantage U.S. fishermen, which would violate provisions of the Magnuson-Stevens Fishery Conservation and Management Act and Atlantic Tuna Convention Act.

The purpose of this study is to estimate the change in incidental catch and bycatch of swordfish, billfish, and other overfished HMS species, as well as sea turtles and marine mammals,

that occur with temporal and spatial restrictions of the use of pelagic longlines in selected areas of the Gulf of Mexico and the U.S. Atlantic Ocean adjacent to the SE U.S. coast. While the issue of incidental catch and bycatch in the pelagic longline fishery could simply be addressed by prohibiting longline gear, this also substantially reduces the amount of target catch landed by U.S. fishermen. Further, meaningful reductions in incidental catches can probably be achieved without a complete prohibition because these catches are not evenly distributed throughout the fishery's range of operation. Therefore, the objectives of the following analysis is to identify possible time/area closure scenarios which would allow NMFS to simultaneously:

(1) maximize the reduction in billfish and small swordfish (< 33 lb) incidental catch;
(2) minimize the reduction in the target catch of swordfish and other species; and
(3) ensure that the incidental catch of other species remains unchanged or is also reduced.

In analyzing the degree to which various time/area closures achieve these objectives, it is necessary to consider what happens to the effort (longline sets) currently occurring in those times and areas which would be closed (i.e., effort displacement). One extreme is to assume no displacement, i.e. there is no reallocation of the sets from the closed area to another location where fishing is allowed. Under this assumption, the results would estimate the maximum possible reduction in incidental catch at the expense of lost target catch. Another alternative assumes that all effort in a closed area is randomly displaced throughout the remaining range open to the fishery (effort reallocation). This assumption produces an estimate of the net effect on incidental and target catch. Although it is recognized that what really would happen probably lies somewhere in between these scenarios, such analysis would require more sophisticated modeling of individual vessel choices in compensating for lost revenues. Such detailed economic and socio-behavioral information is not currently available.

Methods

Pelagic logbook data were used to summarize total monthly U.S. pelagic longline catches (number of each species captured on pelagic longline, whether discarded dead or alive, or retained for sale or personal use) throughout the operational range of the U.S. fleet in the Atlantic Ocean for each of calendar years 1995, 1996 and 1997 (Table 1); Quality Assurance procedures were not completed for the 1998 logbook data at this time. The geographic distribution of discarded and/or kept (as appropriate) swordfish, blue marlin, white marlin, sailfish, spearfish, bluefin tuna, BAYS (bigeye, albacore, yellowfin, and skipjack), pelagic sharks, large coastal sharks, mahi mahi, wahoo, sea turtles, marine mammals, and sea birds from pelagic longline sets was determined by plotting the average number caught per set by latitude and longitude for each quarter (January - March; April - June; July - September; and October - December) from 1993 through 1997 (Figures 1 through 13). For purposes of this analysis, discards are not divided into live or dead discards, since the primary objective of this study is to define a time/area management strategy that minimizes pelagic longline gear interactions with small swordfish, billfish, and other overfished HMS.

These plots were visually examined to identify areas in which most discards of swordfish and billfish occurred. Spatial boundaries around these areas were constructed using as few straight lines as possible to keep their definition as simple as possible (Table 2). A total of four progressively larger areas were identified for the SE U.S. Atlantic coast (SAtlA, SAtlB, SAtlC, SAtlD; Figure 14), and another set of four areas the Gulf of Mexico (GulfA , GulfB, GulfC, GulfD; Figure 15).

Physical characteristics of commercial pelagic longline fishing vessels that have reported at least one pelagic longline set in the logbook data set for 1995 to 1997 in any of the time/area blocks considered in these analyses were described to assist in the evaluation of potential displacement behavior of vessels impacted by area closures.

Time/area Analysis with No Effort Displacement (No Displacement Model)

The effectiveness of time/area closures along the SE U.S. Atlantic coast and Gulf of Mexico under the no displacement model was evaluated by determining the percent reduction in total U.S. Atlantic pelagic longline catch for each month/year block. In some cases, "catch" is kept, in other cases, it is discarded. For swordfish, some are kept, some are discarded. All billfish, sea turtles, and marine mammals are discarded. Because effort is always reduced for the no displacement model, all percent reductions are either negative or zero.

As an example of the calculational procedures, consider the case of area GulfB during January 1995, where 17 blue marlin were reported as discarded (Table 3). A total of 2,924 blue marlin were discarded during 1995 by the entire U.S. Atlantic pelagic longline fishery. Therefore, if all effort in GulfB during January 1995 was removed (309,000 hooks), there would be a corresponding 0.6 percent reduction (17/2,924) in the total annual blue marlin discards by closing GulfB in January. Appendix A summarizes percentage changes for all species, month, year, closure area combinations for the SE U.S. Atlantic coastal area closures, and Appendix A for all Gulf of Mexico closures, respectively.

To determine the effectiveness of the temporal component of the time/area closure strategy for each species and area, cumulative monthly percent changes in catch and discard rates were calculated. Using the same GulfB area as an illustration (Table 3), closure of this area during January (17 blue marlin discarded) and February (11 blue marlin discarded) 1995, Atlantic-wide discards of blue marlin by U.S. pelagic longline fisheries would be reduced by 1 percent (28/2,924). Complete closure of GulfB for 1995 (459 blue marlin were discarded the year from area GulfB) would result in a 16 percent (459/2,924) reduction in total Atlantic discards from U.S. commercial pelagic longline gear. To graphically illustrate the temporal impacts of closing an area, the cumulative monthly percentage change for swordfish kept, swordfish discarded, blue marlin discarded, white marlin discarded, sailfish discarded, bluefin tuna kept and BAYS kept are shown in Figure 16 for GulfB during 1995. Changes in the slope of each line reflect the cumulative effectiveness of the time/area closure. For example, the solid triangle line (blue

marlin) is relatively flat during the months of January to April, then shows a steep shift through September, then remains relatively flat for the remainder of the year indicating that the greatest impact on blue marlin pelagic longline discards occurs if effort is restricted during mid-summer months.

Time/area Analysis with Effort Displacement (Effort Redistribution Model)

It is not realistic to assume that when an area is closed to pelagic longline fishing, that the sets that would have been made in the closed area will not be reallocated elsewhere. However, predicting the magnitude of the shifting effort is problematic, depending upon on several parameters, some of which are not readily quantifiable, including spatial and temporal constraints of the closure, size characteristics of vessels impacting their ability to move to open locations, and socio-economic considerations limiting the ability or willingness of the owner/crew to move to an area closer to where fishing is allowed. The limitations on where that effort would be moved is difficult to accurately assess, therefore, we assumed that fishermen fishing in an area closed in the Gulf of Mexico could potentially move to any open area within the Gulf. A similar assumption was followed for vessels fishing in closed areas along the SE U.S. Atlantic coast, with effort being displaced to other open Atlantic Ocean areas, including the Gulf of Mexico.

The methods used to calculate percent changes in catch rates with displacement of effort are summarized in Table 4, using the same GulfB area employed in the examples above. The first step in the procedure was to determine the monthly catch or discards, and effort (number of hooks) in Gulf B, the Gulf of Mexico, and Atlantic Ocean by U.S. pelagic longline fisheries. The next step in this analysis was to determine the number of each species that were caught in the remaining open areas (E of Table 4), calculated by subtracting the number caught in the closed area from the entire Gulf (B - D). The next step was to determine the catch-per-unit-effort (CPUE) for each species in the remaining open area. This was accomplished by dividing the number of each species caught in the open area (E) by the number of hooks fished in the open area (calculated by subtracting number of hooks in the closed area from those Gulf-wide; A - C). The open-area CPUE was then multiplied by the number of hooks that were used in the closed area to determine the number of additional fish that would be caught in the open fishing areas by the displaced effort (C * F), which was then added to the existing open area catch (E +G) to give the new open area total catches (I). The estimated total catch (I) was then subtracted from the original total number caught in the Gulf (B - H) to estimate the change in number of each species that would be caught as a result of the reallocated effort. This number is equivalent to the value used in the no displacement analysis to represent the number of fish that would not be caught as a result of closure, and the remaining calculations follow the same procedures used for the no displacement model. Because effort is not removed from the system, but redistributed to areas open to pelagic longline fishing, the percentage change calculated under the displaced effort model may be negative (indicating that the closure reduces catch or discards) or positive (the closure results in an increase in catch or discards).

Results

The monthly percent change in catch rates for 1995, 1996, and 1997 are calculated for each of the four closure areas in the SE U.S. Atlantic coast (Appendix A) and four areas in the Gulf of Mexico (Appendix B). Because of the volume of information generated by these analyses, several tables are developed to provide a synopsis of each closure area, by year. Two cases are dropped from further consideration because there is very little difference in the total fishing effort as expressed in number of hooks. GulfD is not included in the Gulf of Mexico summaries due to the similarity of results with GulfC (GulfC represented 93.6 to 97.4 percent of the effort in GulfD). Area SAtlD is not included in the southeastern Atlantic summaries since results are nearly identical to SAtlC (SAtlD represented less than 1 percent additional effort from SAtlC). Table 5 provides a summary, by year and species, of the percent change in total Atlantic-wide catch for closing each SE Atlantic coast area for the entire year with no effort displacement. Percent changes in catch or discards associated with closures in the Gulf of Mexico (no displacement) during March through September are summarized by year, area, and species in Table 6.

Because calculation of percent change uses the total Atlantic-wide catch for every species within each month/closed area block, the percent change calculated for the Gulf of Mexico and SE U.S. Atlantic coastal closures are additive within each month/year block. This allows for an examination of the effectiveness of various time/area combinations between the SE U.S. Atlantic coast (Table 5) and Gulf of Mexico (Table 6). Combinations of each closed area are summarized in Table 7, by year, for swordfish kept, swordfish discarded, blue marlin discarded, sailfish discarded, white marlin discarded, bluefin tuna kept, BAYS kept and mahi mahi kept. Percent change in discards under the effort redistribution model are summarized for the SE U.S. Atlantic coast (Table 8), Gulf of Mexico (Table 9), and combined areas in Table 10. In addition to the time/area closures evaluated in this report, the HMS FMP included a 1 degree latitude by 6 degree longitude pelagic longline closure off the coast of New Jersey during June to reduce bluefin tuna discards by U.S. pelagic longline fisheries. To account for changes in incidental catches and bycatch as a result of all current and potential closures to pelagic longline fishing, the bluefin tuna closure was included in the cumulative impact analysis (Tables 7 and 10).

Time/area closures for the southeastern U.S. Atlantic coast

The time/area options along the SE U.S. Atlantic coast, summarized by area, month, species and year in Appendix A, indicate that year-round closures are the most effective measure to reduce small swordfish, billfish discards. Percent changes in catch and discards are summarized by year, area, and species in Figure 17. Reductions in incidental catch and bycatch under the no displacement model are shown on the left side of the figure, and results of the displacement model (closure areas designated with a “D,” e.g. SAtlA-D) are provided on the right side of each graph.

Blue marlin, white marlin and sailfish discard rates generally increase when effort is displaced from the closed areas along the SE U.S. Atlantic coast to the remaining open areas of the Atlantic and Gulf of Mexico, including locations of relatively high CPUE for billfish in the Caribbean and southwest Atlantic regions (see Table 11). Due to the distance of these areas from the continental United States and the size of many of the vessels operating off Florida, Georgia and South Carolina (Figures 18 to 20), it seems unlikely that much effort will be displaced into the open Caribbean or southwest Atlantic Ocean. To estimate the impact of effort re-distribution on Atlantic billfish discards without the effect of these high CPUE areas, the percent of the total Atlantic-wide billfish discards taken from the Caribbean and southwestern Atlantic (ICCAT areas 93 and 96) are calculated using the procedures outlined in Table 12. These percentages are then used to "adjust" the calculation of the open area CPUEs. The re-calculated percent change in billfish discards are provided, by area, in Table 13 for 1995 to 1997, combined. The values provided in the parentheses show the calculated percent change under the reallocation of effort model that includes all open areas. Removing the billfish catch from the distant water areas in ICCAT areas 93 and 96 probably reflects a "truer" estimate of the impact effort displacement due to closures along the SE US Atlantic coast.

The following section outlines the impacts of the closures under the no displacement and displacement models, starting with the smallest closure area in SE U.S. Atlantic coast, then progressing to the largest area.

Closure of SAtlC during January through December

Closure of the approximately 167,000 square mile SAtlC area along the SE U.S. Atlantic coast during the entire year to pelagic longline gear would impact incidental catch and bycatch as shown in Figure 17 for no displacement and displacement models. Under the no-reallocation of effort model, the following percent reductions could be expected based on 1995, 1996 and 1997 logbook data: swordfish discards, 33 to 46.1%; blue marlin, 12 to 16%; white marlin 6 to 9%; sailfish 17 to 38%; bluefin tuna discards 1 to 5%; and sea turtles 2 to 5%. Associated target species would also experience a reduction in catch, including: swordfish kept 18 to 25%; BAYS 7 to 9%; mahi mahi 45 to 59%; and pelagic sharks 9 to 12%. When reallocation of effort is modeled, some of the impacts on target species are mitigated, and in fact some show a positive percent change indicating that catch rates would increase under this time/area alternative, including: BAYS 6 to 11%; and pelagic sharks 7 to 10%. Under the re-distribution of effort model for SAtlC, Mahi mahi landings would still be significantly reduced, in the order of 34 to 49%. Swordfish discards would still be reduced under the effort re-distribution model (range of 23 to 32%), as would sailfish discards (up to 24%); however the catch of some overfished HMS could potentially increase, including: blue marlin (7 to 15%), white marlin (10 to 18%), bluefin tuna discards (7%), and sea turtle (8 to 13%) catch rates would increase. As noted above, the pelagic longline effort redistribution model moves effort throughout the open Atlantic region, including the Caribbean and southwest Atlantic where billfish catches occur relatively more frequently. The positive percent increases estimated for closure of SAtlC for billfish may be over-

estimated based on the likelihood of the relatively small pelagic longline vessels moving from the near-coastal waters along Florida to distant water areas in the Caribbean and southwest Atlantic. When the effort redistribution estimates are "adjusted" for 1995 to 1997, as discussed above, closure of SAtlC results in reductions of 14% for blue marlin (from an increase of 9%) and 16% for sailfish (from a 9 percent decrease), and an increase of 9% for white marlin (from 12.6%).

Closure of SAtlA during January through December

Closure of the approximately 240,000 square mile SAtlA area along the SE U.S. Atlantic coast during the entire year to pelagic longline gear would impact incidental catch and bycatch as shown in Figure 17 for no displacement and displacement models. Under the no-reallocation of effort model, the following percent reductions could be expected: swordfish discards 37 to 47%; blue marlin 13 to 18%; white marlin 8 to 14%; sailfish 17 to 38%; bluefin tuna discards 2 to 6%; and sea turtles 3 to 4%. As found for area SAtlC, associated target species would also experience a reduction in catch, including: swordfish kept 19 to 26%; BAYS 8 to 11%; mahi mahi 46 to 61%, and pelagic sharks 11 to 15%. When reallocation of effort is modeled, some of the impacts on target species are mitigated, and in fact some show a positive percent change indicating that catch rates would increase under this time/area alternative, including: BAYS 6 to 12% and pelagic sharks 7 to 12%. Under the reallocation of effort model for SAtlA, mahi mahi landings would still be significantly reduced, in the order of 32 to 50%. Swordfish discards would still be reduced under the effort re-distribution model (range of 21 to 30%), as would sailfish discards (12 to 20%); however, blue marlin (10 to 19%), white marlin (10 to 19%), bluefin tuna discards (6 to 10%), and sea turtle (8 to 15%) incidental catch rates would increase. When the effort redistribution estimates are "adjusted" for 1995 to 1997, as discussed above, closure of SAtlA results in reductions of 14% for blue marlin (from an increase of 12%) and 13% for sailfish (from 6%), and an increase of 8% for white marlin (from 13%).

Closure of SAtlB during January to December

Closure of the approximately 250,000 square mile SAtlB area along the SE U.S. Atlantic coast during the entire year to pelagic longline gear would impact incidental catch and bycatch as shown in Figure 17 for no displacement and displacement models. The degree of effectiveness of this closure is difficult to accurately assess, but under a model of no-reallocation of effort, the following percent reductions (from total U.S. Atlantic pelagic longline effort) could be expected: swordfish discards 38 to 48%; blue marlin 13 to 18%; white marlin 10 to17%; sailfish 17 to 39%; bluefin tuna discards 3 to 11%; and sea turtles 3 to 6%. However, associated target species would also experience a reduction in catch, including: swordfish kept 20 to 27%; BAYS 13 to 21%; mahi mahi 49 to 63%; and pelagic sharks 31 to 40%. When reallocation of effort is modeled, some of the impacts on target species are moderated, and in fact some show a positive percent change indicating that catch rates would increase for some of the years modeled under

this time/area alternative, including: swordfish kept by 4% and BAYS by 10%. Pelagic sharks would decline by 9 to 21% under the reallocation of effort model for SAtlB; Mahi mahi landings would also be reduced by 31 to 51%. Swordfish discards would still be reduced under the effort re-distribution model (range of 28 to 28%), as would sailfish discards (up to 15%); however, blue marlin (15 to 25%), white marlin (12 to 23%), bluefin tuna discards (4 to 10%), and sea turtles (13 to 21%) catch rates would increase. When the effort redistribution estimates are "adjusted" as discussed above for 1995 to 1997, closure of SAtlB results in reductions of 9% for blue marlin (from a 19% increase) and 7% for sailfish (from an increase of 1%), while white marlin discards still increase by 8% (from 15%).

Time/area closures for the Gulf of Mexico

Examination of the tables and figures in Appendix B show that closures in the Gulf of Mexico are generally most effective in reducing bycatch and incidental catch of overfished HMS, and protected or endangered species during March through September of each year. A summary is provided in Table 6 of the percent change, by year and species, in total Atlantic-wide catch for closing each respective Gulf of Mexico area for the months of March through September with no effort displacement. When effort from the closed areas during March through September in the Gulf of Mexico are displaced into the remaining open areas in the Gulf, the impacts of the closed areas are mitigated for most target catch species (BAYS and swordfish kept), with several showing higher catch rates than would occur with no closures (Table 9). Percent changes in catch and discards are summarized by year, area, and species in Figure 21. Reductions in incidental catch and bycatch under the no displacement model are shown on the left side of the figure, and results of the displacement model (closure areas designated with a "D," e.g. GulfB-D) are provided on the right side of each graph.

The following discussion outlines the impacts of the closures under the no displacement and displacement models, starting with the smallest closure area in the Gulf of Mexico, then progressing to the largest area.

<u>Closure of GulfA during March through September</u>

Closure of the approximately 47,000 square mile GulfA area in the Gulf of Mexico during June through August to pelagic longline gear would reduce the incidental catch of Atlantic billfish, as shown in Figure 21. Under the no-reallocation of effort model, the following percent reductions could be expected: blue marlin, 4 to 8%; white marlin, 4 to 8%; sailfish, 6 to 14%; swordfish discards, 1 to 3%; bluefin tuna discards, 0 to 1%; and sea turtles, 0%. As found for time/area closures along the SE U.S. Atlantic coast, associated target species would also experience a reduction in catch with closure management strategies in the Gulf of Mexico under a no-reallocation of effort scenario. Target catch rates would potentially be reduced by 1 to 2% for swordfish kept, 4 to 6% for BAYS, and 2 to 3% for mahi mahi. When reallocation of effort is modeled, some of the impacts on target species are mitigated, and in fact some show a positive

percent change indicating that catch rates would increase under this time/area alternative, including: mahi mahi, 2 to 5%; LCS, 0 to 6%, and swordfish kept 0 to 1%. Other target species would be reduced under the effort redistribution model for GulfA, including bluefin tuna kept up to 3.1%, and BAYS, up to 2%). Under the re-distribution of effort model for GulfA, swordfish discards (1 to 2%), and sea turtle encounters (0 to 1%) would increase, but discards would still be reduced for sailfish up to 8%, blue marlin up to 5%, white marlin up to 4%, and bluefin tuna, 2%.

Closure of GulfB during March through September

Closure of the approximately 68,000 square mile GulfB area in the Gulf of Mexico during June through August to pelagic longline gear would reduce the incidental catch of Atlantic billfish, as shown in Figure 21. Under the no-reallocation of effort model, the following percent reductions could be expected: blue marlin, 8 to 14%; white marlin, 12 to 16%; sailfish, 9 to 26%; swordfish discards 3 to 4%; bluefin tuna discards up to 1%; and sea turtles up to 2%. As found for time/area closures along the SE U.S. Atlantic coast and Gulf of Mexico, associated target species would also experience a reduction in catch, including a decrease of up to 3% for swordfish kept, 13% for BAYS, and 7% for mahi mahi. When reallocation of effort is modeled, some of the impacts on target species are mitigated, and in fact some show a positive percent change indicating that catch rates would increase under this time/area alternative, including: mahi mahi, 3.0 to 16%; pelagic sharks kept, up to 2%; and swordfish kept, up to 3%. Under the re-distribution of effort model for GulfB, swordfish discards would increase (range of 3 to 8%), but discards would still be generally be reduced for sailfish (up to 14%), blue marlin (to 13%), white marlin (up to 14%), bluefin tuna (to 1%) and sea turtles (to 1%).

Closure of GulfC during March through September

Closure of the approximately 126,000 square mile GulfC during March through September would greatly reduce the pelagic longline effort in the Gulf of Mexico for this time frame since 93.6 to 97.4 percent (1995 through 1997) of the reported longline effort occurs within the spatial boundaries of this area. Under the no-reallocation of effort model, the following percent reductions could be expected from closing GulfC: blue marlin,12 to 17%; white marlin 17 to 19%; sailfish, 24 to 33%; swordfish discards, 7 to 9%; bluefin tuna discards,1 to 7%; and sea turtles, 0 to 2%. As found for the previous time/area closures, associated target species would also experience a reduction in catch with closure management strategies in the Gulf of Mexico for area GulfC, including a 4% decrease in swordfish kept, 7 to 24% decrease in landings of BAYS, and 14 to 23% for mahi mahi.

Several species exhibited skewed percent changes in catch values when reallocation of effort was modeled for area GulfC. This result is likely due to the fact that GulfC represents approximately 97 percent of the spatial constraints used to define the Gulf of Mexico. When the

calculations were made to re-distribute the effort from GulfC to the remaining open areas of the Gulf of Mexico, bycatch and incidental catch rates increases at a higher percent than noted in other closure areas, particularly for sailfish which experienced an increase in discard rates of 47 to 81%, large coastal sharks kept (7 to 60%) and discarded (26 to 68%), and swordfish discarded (15 to 45%). In light of the magnification of catch rates resulting from displacing large amounts of effort into a relatively small geographic area, results of the displaced model for GulfC should be viewed with some caution. As noted for the other closures under the reallocation of effort model, some of the impacts on target species are mitigated, and in fact some show a positive percent change indicating that catch rates would increase under this time/area alternative, including: mahi mahi, 7 to 58%, and swordfish kept 3 to 15%. Under the re-distribution of effort model for GulfC, incidental catch would still be reduced for blue marlin (up to 12%), white marlin (up to 15%), bluefin tuna discards (up to 7%) and sea turtles (up to 2%). Because of the impacts of shifting effort from GulfC to the remaining open area in the Gulf of Mexico (consisting mainly of the west Florida shelf which is not a primary fishing area as shown in Figures 1 through 13), the no displaced effort model may be more appropriate for evaluating the impact of this closure area.

Combined Impacts of Closures in SE Atlantic coast and Gulf of Mexico

The following Gulf of Mexico and SE U.S. Atlantic coast closures were examined to provide estimates of cumulative impacts on incidental catch and bycatch that might be achieved under various time/area combinations. Closures of the bluefin tuna area was also included in these analysis to model the full extent of possible time/area impacts.

Closure of GulfB (March to September) and SAtlC (January to December)

This alternative would close the smallest area in SE U.S. Atlantic area (SAtlC) during January through December and the mid-sized area in the Gulf of Mexico (GulfB) for March through September. The SAtlC +GulfB closure would eliminate approximately 235,000 square miles of ocean to the use of pelagic longline gear by U.S. commercial fishermen. When the June bluefin tuna closure was included in the evaluation of the no effort displacement model from the 1995 to 1997 pelagic logbook database, the following percent reductions of incidental catch and bycatch (Figure 22) were noted: swordfish discards, 42%; blue marlin discards, 25%; white marlin discards, 22%; spearfish discards, 9%; sailfish discards, 42%; bluefin tuna discards, 60%; and sea turtles, 5%. Under the no reallocation of effort model, target and incidental landings are also reduced, including; swordfish, 26%; BAYS, 19%; mahi mahi, 61%, pelagic sharks (kept and discarded), 13% and 5%, respectively; large coastal sharks (kept and discarded), 38% and 50%, respectively, and bluefin tuna kept, 36% reduction.

Under the reallocation of effort model, the SAtlC+GulfB closure, together with the bluefin tuna June closure, provided the following percent reductions in bycatch and incidental catches for 1995 to 1997, including: swordfish discards, 23%; bluefin tuna discards, 48%, and sailfish

discards, 10%. The discards of blue marlin and white marlin increased by 5% and 6%, respectively, when effort was displaced from the SAtlC+GulfB closure; however, as previously discussed for the SE U.S. Atlantic coastal closures, these percentages may be unrealistically high based on the probability of effort from this closure being moved to the Caribbean and SW Atlantic where billfish discards can occur at a higher frequency. Using the billfish adjustment factor (see Appendix B), blue marlin discards for the SAtlC+GulfB closure would be reduced to 11%, sailfish would be reduced by 14%, and white marlin would experience a 0.5% reduction in discards under this closure option. Target landings of swordfish were reduced under this closure alternative (6%), as were mahi mahi (35%), but landings of several target species increased when pelagic longline effort was reallocated, including an 8% increase in BAYS, and 9% increase in pelagic sharks. The incidental catch of sea turtles also increased (9%) with pelagic longline effort redistribution.

Closure of GulfB (March to September) and SAtlB (January to December)

This alternative would close the largest area in SE U.S. Atlantic area (SAtlB) during January through December and the mid-sized area in the Gulf of Mexico (GulfB) for March through September. The SAtlB+GulfB closure would eliminate approximately 320,000 square miles of ocean to the use of pelagic longline gear by U.S. commercial fishermen. When the June bluefin tuna closure was included in the evaluation of the no effort displacement model from the 1995 to 1997 pelagic logbook database, the following percent reductions of incidental catch and bycatch (Figure 23) were noted: swordfish discards, 45%; blue marlin discards, 27%; white marlin discards, 28%; spearfish discards, 11%; sailfish discards, 43%; bluefin tuna discards, 64%; and sea turtles, 6%. Under the no reallocation of effort model, target and incidental landings are also reduced, including; swordfish, 28%; BAYS, 31%; mahi mahi, 67%, pelagic sharks (kept and discarded), 37% and 11%, respectively; large coastal sharks (kept and discarded), 67% and 66%, respectively, and bluefin tuna kept, 43%. The reallocation of effort model for the SAtlB+GulfB closure, together with the bluefin tuna June closure, provided the following reductions in percent change in bycatch and incidental catches for 1995 to 1997, including swordfish discards, 20%; and bluefin tuna discards, 47%. The discards of all Atlantic billfish increased when effort was displaced from the SAtlB+GulfB closure, including: blue marlin, 15%; white marlin, 9%, sailfish, 0.3% and spearfish, 32%; however, using the billfish adjustment factor discussed above, blue marlin discards for this closure would be reduced by 10%, by 7% for sailfish and by 2% white marlin. Landings of mahi mahi were reduced under this closure alternative (37%), as were pelagic sharks (13%), but landings of other target species increased, including: swordfish, 1% and BAYS 5%. The bycatch of sea turtles also increased (16%) with pelagic longline effort redistribution.

Closure of GulfC (March to September) and SAtlB (January to December)

This alternative would close the largest area in SE U.S. Atlantic area (SAtlB) during January through December and the largest area in the Gulf of Mexico (GulfC) for March through September. The SAtlB+GulfB closure would eliminate approximately 375,000 square miles of

ocean to the use of pelagic longline gear by U.S. commercial fishermen. When the June bluefin tuna closure was included in the evaluation of the no effort displacement model from the 1995 to 1997 pelagic logbook database, the following reductions in percent change of incidental catch and bycatch (Figure 24) were noted: swordfish discards, 50%; blue marlin discards, 30%; white marlin discards, 33%; spearfish discards, 12%; sailfish discards, 55%; bluefin tuna discards, -65%; and sea turtles, 7%. Under the no reallocation of effort model, target and incidental landings are also reduced, including; swordfish, 30%; BAYS, 38%; mahi mahi, 79%; pelagic sharks (kept and discarded), 39% and 12%, respectively; large coastal sharks (kept and discarded), 73%; and bluefin tuna kept, 52%.

Evaluation of the reallocation of effort model for the SAtlB+GulfC closure must be made with caution. As noted under the discussion of the GulfC closure, GulfC represents approximately 97 percent of spatial definition of the Gulf of Mexico, and nearly 95% of all pelagic longline effort and catches in the Gulf. Compressing all effort into the remaining open areas caused the reallocation of effort model to yield skewed results for several species. Combining the SAtlB+GulfC closure with the bluefin tuna June closure, the following increases in percent change in bycatch and incidental catches were noted for 1995 to 1997, including: swordfish discards, 12%; blue marlin, 16%; white marlin, 14%, sailfish, 48% and spearfish, 30%; bluefin tuna discards decreased by 49%. Landings of some target species decreased under the SAtlB+GulfC reallocated effort closure scenario, including BAYS (11.0%), mahi mahi (29%), bluefin tuna (16%), and pelagic sharks (6%), but landings of other target species increased (swordfish, 12%; large coastal sharks, 35%). The incidental catch of sea turtles increased by 15% with pelagic longline effort redistribution.

A comparison of the three Gulf of Mexico and South Atlantic closure options is presented in Table 14. Under the displaced model for blue marlin, white marlin and sailfish, the percent change values are adjusted for Caribbean and southwestern Atlantic catches. In addition, for Gulf C+SAtlB areas, the percent change values for both the displaced and no displaced models are used for GulfC, using the rationale outline above.

Discussion

There are inherent problems associated with the use of self-reported data in fisheries management. Cramer and Adams (1998) note that significant under-reporting of incidental catch in logbooks is apparent when logbooks are compared to observer data, except in the case of blue sharks. Blue sharks are discarded for economic reasons but are prolific in the catch and are such a nuisance to fishermen that they tend to over-report these encounters in logbook data when compared to observer data. As of July 1, 1999, NMFS requires all fishermen to complete their logbook forms within 48 hours of a set, intending to facilitate enforcement and to increase the accuracy of the report. If the magnitude of under-reporting of incidental catch and bycatch was independent of year, season, or geographic location, then the effects on the analysis would not be a major concern, which is why percentages are used in the analyses provided in this report, rather

than actual numbers. Due to time constraints, NMFS cannot, at this time, analyze observer records by species and geographic region to estimate the degree of mis-reporting in logbooks for this evaluation of closed areas. This would, however, be an interesting analysis in the future which would supplement the Cramer and Adams (1998) analysis, and may be useful for evaluating the efficacy of the closed areas, once implemented.

The time/area analyses included in this report are aimed at addressing incidental catch by U.S. pelagic longlines. However, it was difficult to separate pelagic longline vs. bottom longline sets in the database. This was particularly evident in the results relating to kept and discarded large coastal sharks, under several of the time/area scenarios. NMFS attempted to "clean up" the database by eliminating sets that were clearly bottom longline sets. It is possible that some of the data used (catch, discard, and effort) may have been derived from bottom longline sets. NMFS also notes that defining the way longline gear is set is sometimes difficult as some pelagic longline fishermen may re-rig their gear, even within a trip, to target sharks. Because the bottom longline fishery has lower incidental catch rates than the pelagic longline fishery, the addition of bottom longline sets would likely reduce the average incidental catch rate overall, not increase it. Moreover, this artifact of the data would only have a practical effect on the conclusions of these analyses if the bottom longline sets were predominately in the closed areas, lowering estimates of incidental catch reduction in the effort displacement scenarios, or in the open areas, thereby overestimating the potential gains. The effects would be negligible if both longline sets are randomly distributed relative to one another.

Closures in the Gulf of Mexico during March through September, and along the SE U.S. Atlantic coast throughout the year will reduce discard rates under the no displacement model. When these areas are combined with the bluefin tuna June closure, swordfish discards are reduced 40 to 50%, blue marlin by 19 to 29%, white marlin 13 to 33 percent, sailfish 37 to 55 percent, spearfish 8 to 12%, bluefin tuna discards 60 to 65% and sea turtles 4 to 7%. However, there will also be adverse impacts on catch of target species, with catches reduced by up to 39 percent for BAYS, 80 percent for mahi mahi and 29 percent for swordfish kept. Closures also impact landings and discards of sharks, mainly as a result of the SE U.S. Atlantic closures, where large coastal shark landings and discards from pelagic longline gear (as opposed to bottom longline gear which is the primary gear for this fishery) decline by 73 and 70 percent, respectively. Pelagic sharks experience a reduction of 11 to 46 percent in landings, with approximately 10 percent fewer discards.

Negative consequences of the closures on target species catch rates are partially mitigated when displaced effort impacts are included in the analysis of time/area closures. The estimated effects on the catch of BAYS range from a 11 percent reduction (mainly associated with effort redistribution from the GulfC closure) to a 8 percent increase in landings, while swordfish landings range from a 6 percent reduction to a 12 percent increase. Landings of mahi mahi are reduced up to 39 percent.

Time/area closures appear to be an effective way to reduce incidental catch by U.S. pelagic longlines. However, it is likely that target species catches will be affected, particularly the yellowfin tuna fishery in the Gulf of Mexico and the mahi mahi fishery along the SE U.S. Atlantic coast. Some consequences may be mitigated by possible conversion to gear that does not have similar impacts as pelagic longline gear (e.g., mahi fishery perhaps could convert to a rod and reel fishery). Communities along the Gulf of Mexico and SE U.S. Atlantic coasts are very fishing-oriented and fishermen are not likely to move out of these communities as a result of the closure to longline fishing. Instead, these fishermen are expected to pursue other commercial fisheries in which they hold permits or other non-fishing activities. Fishermen who exit the fishery may realize compensation from the sale of their limited access swordfish, shark, and tuna permits. In addition, the industry is pursuing a legislative buyout program which may mitigate economic impacts to vessels who expend a greater proportion of their pelagic longline effort in the proposed closed areas.

While time/area closures may be an effective way to minimize incidental catch of these species in the U.S. pelagic longline fishery, particularly along the U.S. EEZ, these species are also targeted by international pelagic longline fleets that do not discard billfish and small swordfish. Any reductions in incidental catch must be evaluated in terms of the U.S. catch relative to total stock-wide mortalities. International time/area closures may be an option to address stock-wide mortality from incidental catch of billfish and small swordfish. The United States will be negotiating for rebuilding programs for swordfish and billfish through ICCAT in 1999 and 2000, respectively.

Another likely impact of time/area closures will be a reduction in user-group conflicts between recreational and commercial fisheries, particularly for Atlantic billfish. The issue of user-conflicts was one of the major problems identified in the 1988 Atlantic Billfish FMP. The recreational billfish fishery has grown in size and value over the past decade, although many anglers have increased effort outside the United States to locations with greater fishing success. Any management measure leading to a reduction in incidental catch of billfish from commercial fishing gear, may lead to localized increases in angler success and resultant economic benefits to associated U.S. recreational industries.

Conclusion

NMFS will continue to evaluate environmental, social, and economic impacts of the alternatives for closing areas in the Gulf of Mexico and the Atlantic Ocean off the Southeast coast of the United States to pelagic longline fishing in order to minimize incidental catch. While a complex model of fishing effort re-distribution may provide more details into the expected results of such a closure, NMFS anticipates that the general approach described above accurately estimates the possible benefits of reducing incidental catch of overfished species. In addition to time/area closures, NMFS continues to work with the commercial fishing industry and research scientists to identify possible gear modifications (e.g., hook type, bait type) which may reduce

incidental catch mortality caused by interactions with longline gear.

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Table 1. Number of fish reported in pelagic longline logbooks, by year and area, for U.S. commercial fishermen.

Species	1995			1996			1997		
	Total	GOM[1]	Atlantic	Total	GOM	Atlantic	Total	GOM	Atlantic
Swordfish Kept	72,773	6,694	66,079	73,169	7,342	65,827	68,253	5,178	63,075
Swordfish Discarded	29,176	4,566	24,610	23,808	4,293	19,515	20,483	3,214	17,269
Blue Marlin Discarded	2,924	505	2,419	3,280	452	2,828	2,605	492	2,113
White Marlin Discarded	3,283	672	2,611	2,822	693	2,129	2,776	524	2,252
Sailfish Discarded	1,124	442	682	1,430	475	955	1,714	508	1,206
Spearfish Discarded	368	2	366	549	8	541	3479	16	363
Bluefin Tuna Kept	240	92	148	208	73	135	180	46	134
Bluefin Tuna Discarded	2,848	21	2,827	1,706	28	1,678	679	47	632
BAYS Kept	119,259	24,071	95,188	84,977	27,817	57,160	102,123	30,678	71,445
Pelagic Sharks Kept	5,871	510	5,361	5,279	373	4,906	5,136	259	4,877
Pelagic Sharks Discarded	90,193	488	89,705	84,590	769	83,821	82,235	382	81,853
LCS Kept	58,567	14,984	43,583	36,047	5,861	30,186	21,741	1,651	20,090
LCS Discarded	11,033	1,167	9,866	11,486	2,260	9,226	8,026	1,290	6,736
Mahi Kept	71,541	11,423	60,118	37,007	9,684	24,323	63,056	11,701	51,355
Wahoo Kept	4,930	3,605	1,325	3,468	2,391	1,077	4,569	3,074	1,495
Turtles Caught	1,142	42	1,100	498	15	483	267	4	263
Number of Hooks (X 1,000)	11,036	2,818	8,218	10,617	3,058	7,559	9,873	2,682	7,191

[1]Gulf of Mexico logbook reports estimated by area bounded by GulfD (Figure 15).

Table 2. Spatial boundaries for closures within the Gulf of Mexico and along the SE U.S. Atlantic coast.

	Area Closed	North Boundary	East Boundary	South Boundary	West Boundary
Gulf of Mexico	GulfA	Coast line	92º W long.	26º N lat.	Coast line
	GulfB	Coast line	90º W long.	26º N lat.	Coast line
	GulfC	Coast line	86º W long.	26º N lat.	Coast line
	GulfD	Coast line	82º W long.	26º N lat.	Coast line
SE U.S. Atlantic Coast	SAtlA	34º N lat.	74º W long.	24º N lat.	Coast line - 82º W long.
	SAtlB	36º N lat.	74º W long.	24º N lat.	Coast line - 82º W long.
	SAtlC	34º N lat.	76º W long.	24º N lat.	Coast line - 82º W long.
	SAtlD	36º N lat.	76º W long.	24º N lat.	Coast line - 82º W long.

Table 3. Example of temporal variations in the effectiveness of closing area GulfB during 1995.

Month (1995)	Number Blue Marlin in GulfB	Cumulative Number Caught	Percent Change Atlantic-wide
January	17	17	-0.58
February	11	28	-0.96
March	3	31	-1.06
April	4	35	-1.20
May	33	68	-2.33
June	104	172	-5.88
July	169	341	-11.66
August	72	413	-14.12
September	13	426	-14.57
October	12	438	-14.98
November	7	445	-15.22
December	14	459	-15.70

Table 4. Calculation procedures for estimating dispersion of effort using 1995 blue marlin in GulfB. A total of 2,924 Blue marlin were discarded (alive + dead) in 1995 from U.S. pelagic longline gear.

	A	B	C	D	E	F	G	H	I	J	K
Month	Number of hooks in GOM[2]	Number of blue marlin caught in GOM	Number of hooks in GulfB	Number of blue marlin caught in GulfB	Number of BUM in open GOM area: (B - D)	BUM CPUE in open GOM area: (E/(A-C))	Number additional BUM caught in open GOM area by displaced effort: (C * F)	BUM catch from open GOM area with displaced effort: (E + G)	Number BUM avoided by area closure: (B - H)	Cumulative catch by month (sum of I)	Percent of total US BUM discards avoided by closure: (J/29.24)
Jan	309,000	20	211,000	17	3	3.06E-05	6.46	9.46	10.54	10.54	-0.36
Feb	234,000	15	143,000	11	4	4.4E-05	6.29	10.29	4.71	15.26	-0.52
Mar	213,000	4	129,000	3	1	1.19E-05	1.54	2.54	1.46	16.72	-0.57
Apr	214,000	5	131,000	4	1	1.2E-05	1.58	2.58	2.42	19.14	-0.65
May	267,000	35	148,000	33	2	1.68E-05	2.49	4.49	30.51	49.65	-1.7
June	264,000	104	177,000	104	0	0	0	0	104	153.65	-5.25
July	318,000	175	151,000	169	6	3.59E-05	5.42	11.42	163.58	317.23	-10.85
Aug	255,000	83	126,000	72	11	8.53E-05	10.74	21.74	61.26	378.48	-12.94
Sep	289,000	21	126,000	13	8	4.91E-05	6.18	14.18	6.82	385.3	-13.18
Oct	124,000	20	73,030	12	8	1.57E-04	11.46	19.46	0.54	385.84	-13.19
Nov	160,000	9	133,000	7	2	7.41E-05	9.85	11.85	-2.85	382.99	-13.1
Dec	171,000	14	142,000	14	0	0	0	0	14	396.99	-13.6
Total	2,818,000	505	1,690,030	459	46	4.08-E-05	68.92	114.92			

Table 5. Closures for SE U.S. Atlantic coast during January to December - percent change with NO displacement (smallest to largest

[2]Gulf of Mexico logbook reports estimated by area bounded by GulfD (Figure 15).

closed areas).

Species	SAtlC closed			SAtlA closed			SAtlB closed		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Swordfish Kept	-18.32	-24.99	-25.32	-18.76	-25.76	-25.75	-20.32	-27.02	-27.2
Swordfish Discarded	-33.11	-46.14	-36.93	-33.33	-46.81	-37.29	-37.95	-48.13	-40.24
Blue Marlin Discarded	-12.62	-15.61	-11.94	-13.27	-17.74	-12.59	-14.91	-18.29	-12.82
Sailfish Discarded	-27.58	-37.83	-16.86	-28.11	-38.18	-17.21	-29.18	-38.74	-17.21
Spearfish Discarded	-5.43	-10.02	-6.86	-6.25	-11.66	-11.08	-6.25	-12.56	-11.08
White Marlin Discarded	-7.64	-9	-5.73	-8.92	-13.68	-8.43	-16.29	-17	-9.47
BAYS Kept	-6.72	-7.89	-6.89	-8.23	-11.2	-8.19	-21.05	-21	-12.93
Bluefin Tuna Kept	-5	-9.62	-7.78	-7.08	-16.34	-11.67	-9.58	-18.75	-16.67
Bluefin Tuna Discarded	-0.67	-1.82	-4.56	-1.97	-4.16	-6.33	-2.67	-8.38	-11.34
Pelagic Sharks Kept	-8.65	-12.10	-10.55	-11.96	-15.00	-11.39	-31.27	-32.63	-40.11
Pelagic Sharks Discarded	-1.71	-3.08	-2.73	-1.97	-3.51	-2.99	-8.24	-9.83	-9.3

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Species	SAtlC closed			SAtlA closed			SAtlB closed		
LCS Kept	-29.97	-42.35	-36.25	-37.87	-52.56	-48.2	-59.37	-63.60	-76.21
LCS Discarded	-47.92	-44.18	-47.06	-53.8	-47.59	-54.25	-69.56	-55.48	-63.44
Mahi Kept	-54.67	-44.64	-58.76	-56.74	-45.98	-60.89	-62.42	-49.20	-62.92
Turtles Caught	-1.92	-3.01	-4.49	-2.27	-4.21	-4.87	-2.89	-5.42	-5.99

Table 6. Closures for the Gulf of Mexico areas during June to August - percent change with NO displacement

Species	BillA			GulfB			GulfC		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Blue Marlin discarded	-4.00	-4.08	-8.21	-13.61	-8.38	-11.75	-14.53	-12.07	-16.62
Sailfish discarded	-13.26	-13.84	-6.01	-26.16	-16.08	-8.69	-32.8	-28.53	-23.69
Spearfish discarded	0	-0.54	0	-0.27	-1.09	-0.53	-0.27	-1.27	-3.96
White Marlin discarded	-3.84	-4.03	-7.6	-15.75	-12.22	-11.89	-16.81	-19.28	-17.72
Swordfish Kept	-1.56	-1.20	-1.40	-2.96	-2.07	-2.10	-4.47	-4.25	-4.27
Swordfish Discarded	-1.29	-1.77	-2.66	-3.21	-3.12	-4.10	-6.58	-7.60	-9.45
BAYS Kept	-4.06	-6.52	-6.45	-8.53	-12.47	-11.16	-7.07	-24.45	-20.38
Bluefin Tuna Kept	-8.75	-13.46	-4.44	-21.67	-25.00	-10.56	-33.75	-30.77	-18.89
Bluefin Tuna Discarded	-0.17	-1.00	-0.44	-0.56	-1.41	-1.32	-0.67	-1.64	-6.92
Pelagic Sharks Kept	-1.15	-1.10	-0.84	-2.09	-2.27	-1.15	-3.82	-4.05	-3.52
Pelagic Sharks Discarded	-0.03	-0.14	-0.08	-0.11	-0.25	-0.16	-0.14	-0.52	-0.34
LCS Kept	-0.70	-0.29	-0.15	-4.40	-1.45	-0.20	-13.84	-4.80	-2.02
LCS Discarded	-0.45	-0.61	-1.54	-1.45	-5.60	-1.93	-4.78	-13.88	-11.42

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Species	BillA			GulfB			GulfC		
Mahi Kept	-2.52	-1.82	-1.64	-7.24	-4.70	-3.88	-14.20	-22.62	-16.99
Turtles Caught	-0.28	-0.20	0	-2.19	-0.80	-0.37	-2.53	-2.41	-0.37

Table 7. Cumulative impact of closures of areas in the Gulf of Mexico (March through September), SE U.S. Atlantic coast (January to December), and the bluefin tuna closure (June) on target species with NO displacement (alternatives are shaded).

Year	Closed Areas	Swords Kept	Swords Discard	BUM Discard	SAI Discard	WHM Discard	BFT Discard	BAYS Kept	Mahi Kept
95	GulfA+SAtlC+BFT	-20.31	-34.47	-16.65	-40.83	-11.79	–62.74	-12.63	-58.2
	GulfA+SAtlA+BFT	-20.75	-34.69	-17.30	-41.37	-13.07	-64.04	-14.14	-60.25
	GulfA+SAtlB+BFT	-22.32	-39.31	-18.94	-42.44	-20.44	-64.75	-26.96	-65.92
	GulfB+SAtlC+BFT	-21.72	-36.38	-26.26	-53.73	-23.70	-34.17	-17.10	-62.89
	GulfB+SAtlA+BFT	-22.16	-36.61	-26.92	-54.27	-24.98	-64.43	-18.61	-64.97
	GulfB+SAtlB+BFT	-23.73	-41.23	-28.56	-55.34	-32.35	-65.13	-31.42	-70.64
	GulfC+SAtlC+BFT	-23.22	-39.75	-27.19	-60.41	-24.76	-63.24	-20.98	-69.85
	GulfC+SAtlA+BFT	-23.66	-39.97	-27.84	-60.94	-26.04	-64.53	-22.49	-71.92
	GulfC+SAtlB+BFT	-25.23	-44.59	-29.48	-62.01	-33.41	-65.24	-35.30	-77.60
96	GulfA+SAtlC+BFT	-26.50	-47.94	-19.79	-51.68	-14.53	-59.49	-16.99	-48.80
	GulfA+SAtlA+BFT	-27.27	-48.61	-21.92	-52.03	-19.21	-61.84	-20.30	-50.13
	GulfA+SAtlB+BFT	-28.54	-49.93	-22.47	-52.59	-22.53	-66.06	-30.10	-53.36
	GulfB+SAtlC+BFT	-27.37	-49.29	-24.08	-53.92	-22.71	-59.91	-22.94	-51.67
	GulfB+SAtlA+BFT	-28.14	-49.96	-26.22	-54.26	-27.39	-62.25	-26.25	-53.00
	GulfB+SAtlB+BFT	-29.40	-51.28	-26.77	-54.82	-30.72	-66.47	-36.05	-56.23
	GulfC+SAtlC+BFT	-29.56	-53.77	-27.77	-66.36	-29.77	-60.14	-34.92	-69.60

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Year	Closed Areas	Swords Kept	Swords Discard	BUM Discard	SAI Discard	WHM Discard	BFT Discard	BAYS Kept	Mahi Kept
	GulfC+SAtlA+BFT	-30.32	-54.44	-29.91	-66.71	-34.44	-62.48	-38.23	-70.94
	GulfC+SAtlB+BFT	-31.59	-51.28	-26.77	-54.82	-30.72	-66.47	-36.05	-74.16
97	GulfA+SAtlC+BFT	-27.21	-39.62	-20.19	-22.87	-13.58	-48.31	-14.36	-62.26
	GulfA+SAtlA+BFT	-27.63	-39.98	-20.84	-23.22	-16.28	-50.07	-15.67	-64.38
	GulfA+SAtlB+BFT	-29.07	-42.93	-21.07	-23.22	-17.33	-55.08	-20.41	-66.42
	GulfB+SAtlC+BFT	-27.91	-41.06	-23.72	-25.55	-17.87	-49.19	-19.07	-64.50
	GulfB+SAtlA+BFT	-28.34	-41.42	-24.38	-25.90	-20.57	-50.96	-20.38	-66.63
	GulfB+SAtlB+BFT	-29.78	-44.37	-24.61	-25.90	-21.61	-55.96	-25.12	-68.66
	GulfC+SAtlC+BFT	-30.07	-46.42	-28.60	-40.54	-23.70	-54.79	-28.29	-77.62
	GulfC+SAtlA+BFT	-30.50	-46.77	-29.25	-40.90	-26.40	-56.55	-25.60	-79.74
	GulfC+SAtlB+BFT	-31.95	-49.72	-29.48	-40.90	-27.44	-61.56	-34.24	-81.79
95-97	GulfA+SAtlC+BFT	-24.62	-40.27	-18.87	-37.25	-13.22	-59.81	-14.42	-57.65
	GulfA+SAtlA+BFT	-25.17	-40.68	-20.07	-37.65	-16.02	-61.51	-16.36	-59.58
	GulfA+SAtlB+BFT	-26.60	-43.76	-20.89	-38.12	-20.13	-63.92	-25.65	-63.40
	GulfB+SAtlC+BFT	-25.62	-41.87	-24.70	-42.48	-21.56	-60.27	-19.37	-61.07
	GulfB+SAtlA+BFT	-26.17	-42.28	-25.90	-42.88	-24.37	-61.97	-21.32	-62.99
	GulfB+SAtlB+BFT	-27.60	-45.36	-26.72	-43.34	-28.48	-64.38	-30.60	-66.81
	GulfC+SAtlC+BFT	-27.57	-46.15	-27.82	-54.43	-26.02	-61.13	-27.28	-72.65

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Year	Closed Areas	Swords Kept	Swords Discard	BUM Discard	SAI Discard	WHM Discard	BFT Discard	BAYS Kept	Mahi Kept
	GulfC+SAtlA+BFT	-28.12	-46.56	-29.03	-54.83	-28.82	-62.83	-29.22	-74.58
	GulfC+SAtlB+BFT	-29.54	-49.64	-29.84	-55.29	-32.93	-65.24	-38.51	-78.39

Table 8. Closures for SE U.S. Atlantic coast January to December - percent change with displacement.

Species	SAtlC closed			SAtlA closed			SAtlB closed		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Swordfish Kept	-4.27	-7.28	-9.03	-2.59	-4.98	-7.84	4.45	-1.01	-5.01
Swordfish Discarded	-22.55	-32.26	-23.39	-21.32	-30.43	-22.32	-19.96	-28.05	-21.74
Blue Marlin Discarded	8.78	6.89	14.73	11.52	10.12	19.44	19.90	15.37	25.35
Sailfish Discarded	-14.19	-23.83	8.46	-13.01	-19.53	12.32	-5.96	-15.22	19.61
Spearfish Discarded	22.75	19.06	26.17	26.2	22.77	26.04	36.82	27.12	32.98
White Marlin Discarded	9.57	11.47	18.16	10.48	11.01	18.58	11.88	13.16	23.05
BAYS Kept	5.95	11.18	10.04	5.60	11.62	10.28	-0.13	6.15	10.19
Bluefin Tuna Kept	15.38	13.42	12.46	16.01	11.49	9.84	22.99	13.94	9.92
Bluefin Tuna Discarded	6.99	7.16	7.06	6.40	7.68	6.54	9.63	5.36	4.05
Pelagic Sharks Kept	8.65	7.45	10.17	6.83	8.74	12.27	-10.72	-9.28	-21.04
Pelagic Sharks Discarded	8.87	14.43	13.18	9.56	16.45	14.91	11.51	17.92	13.41

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Species	SAtlC closed			SAtlA closed			SAtlB closed		
LCS Kept	-13.83	-26.58	-19.37	-20.88	-37.00	-33.51	-45.58	-50.46	-69.41
LCS Discarded	-38.01	-29.32	-33.64	-44.60	-30.19	-41.14	-59.62	-34.90	-50.49
Mahi Kept	-46.45	-34.08	-48.67	-48.1	-31.60	-50.16	-50.97	-30.79	-49.67
Turtles Caught	7.87	13.18	8.98	8.37	14.84	10.04	16.30	21.45	12.85

Table 9. Closures in the GOM for June to August - percent change with displacement

Species	GulfA Closed			GulfB Closed			GulfC Closed		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Blue Marlin Discarded	-0.85	-1.51	-4.91	-12.60	-4.26	-6.61	-11.96	-3.62	1.01
Sailfish Discarded	-4.97	-7.94	2.32	-13.48	1.60	7.93	49.77	47.22	80.93
Spearfish Discarded	0.04	-0.30	1.44	-0.27	-0.89	1.96	-0.27	-1.27	-3.96
White Marlin Discarded	0.46	0.93	-3.77	-14.24	-4.17	-6.09	-14.58	16.95	-6.70
Swordfish Kept	-0.19	0.70	0.09	0.01	2.73	0.83	3.00	14.99	13.22
Swordfish Discarded	1.22	2.32	1.38	3.42	7.81	3.44	14.86	39.77	44.77
BAYS Kept	-1.11	-1.53	-0.18	-4.63	-1.35	-0.79	-10.08	-20.95	-18.66
Bluefin Tuna Kept	1.41	-3.11	-1.54	-0.09	-11.02	-0.53	-23.37	-26.92	-10.00
Bluefin Tuna Discarded	0.01	-0.53	1.69	-0.26	-0.83	2.78	-0.32	-1.52	-6.63
Pelagic Sharks Kept	0.43	0.48	0.19	1.69	0.84	1.18	6.08	9.08	5.80

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Species	GulfA Closed			GulfB Closed			GulfC Closed		
Pelagic Sharks Discarded	0	0	0.03	-0.07	0.04	0.05	0.04	-0.04	0.16
LCS Kept	5.67	2.17	0.11	11.47	5.71	0.36	60.03	23.25	6.87
LCS Discarded	1.91	6.90	4.04	5.37	10.86	10.61	25.81	45.10	68.35
Mahi Kept	1.70	5.18	4.49	2.95	16.54	7.84	6.94	57.84	7.17
Turtles Caught	0.60	0.3	0.16	-1.25	0.38	-0.16	-2.10	-2.41	6.41

Table 10. Cumulative impact of closures of areas in Gulf of Mexico (March to September), SE U.S. Atlantic coast (January to December), and bluefin tuna closure (June) on target species with displacement (alternatives are shaded).

Year	Closed Areas	Swords Kept	Swords Discard	BUM Discard	SAI Discard	WHM Discard	BFT Discard	BAYS Kept	Mahi Kept
95	GulfA+SAtlC+BFT	-3.59	-19.95	9.93	-15.40	11.79	-51.06	4.42	-41.57
	GulfA+SAtlA+BFT	-1.91	-18.72	12.66	-14.21	12.71	-51.65	4.08	-43.26
	GulfA+SAtlB+BFT	5.13	-17.36	21.04	-7.16	14.11	-48.43	-1.66	-46.09
	GulfB+SAtlC+BFT	-3.38	-17.76	-18.3	-23.90	-2.90	-51.33	2.14	-40.32
	GulfB+SAtlA+BFT	-1.70	-16.52	0.90	-22.72	-1.99	-51.93	1.80	-42.02
	GulfB+SAtlB+BFT	5.34	-15.17	9.29	-15.67	-0.59	-48.70	-3.93	-44.85
	GulfC+SAtlC+BFT	-0.39	-6.32	-1.19	39.34	-3.24	-51.39	-4.55	-36.33
	GulfC+SAtlA+BFT	1.29	-5.08	1.54	40.53	-2.33	-51.98	-4.84	-38.02
	GulfC+SAtlB+BFT	8.33	-3.73	9.23	47.58	-0.93	-48.76	-10.63	-40.85
96	GulfA+SAtlC+BFT	-5.46	-28.72	7.53	-28.73	13.53	-48.37	9.61	-23.50
	GulfA+SAtlA+BFT	-3.16	-26.89	10.77	-24.43	13.08	-47.86	10.04	-21.02
	GulfA+SAtlB+BFT	0.81	-24.51	16.01	-20.12	15.22	-50.18	4.58	-20.21
	GulfB+SAtlC+BFT	-3.42	-23.23	4.79	-19.20	8.44	-48.68	9.78	-14.01
	GulfB+SAtlA+BFT	-1.12	-21.40	8.02	-14.9	7.98	-48.16	10.22	-11.54
	GulfB+SAtlB+BFT	2.85	-19.02	13.27	-10.59	10.12	-50.48	4.75	-10.73
	GulfC+SAtlC+BFT	8.83	8.73	5.43	26.42	29.56	-49.36	-9.82	29.17

Year	Closed Areas	Swords Kept	Swords Discard	BUM Discard	SAI Discard	WHM Discard	BFT Discard	BAYS Kept	Mahi Kept
	GulfC+SAtlA+BFT	11.14	10.56	8.66	30.72	29.10	-48.84	-9.34	31.64
	GulfC+SAtlB+BFT	15.11	12.94	13.91	35.03	31.24	-51.17	-14.85	32.45
97	GulfA+SAtlC+BFT	-8.56	-21.43	10.87	12.17	15.14	-33.16	9.57	-42.80
	GulfA+SAtlA+BFT	-7.37	-20.36	15.58	16.03	15.56	-33.69	9.80	-44.28
	GulfA+SAtlB+BFT	-4.53	-19.78	21.49	23.31	20.02	-36.18	9.71	-43.80
	GulfB+SAtlC+BFT	-7.82	-19.37	9.16	17.78	12.82	-32.07	8.95	-39.45
	GulfB+SAtlA+BFT	-6.64	-18.30	13.88	21.64	13.25	-32.59	9.18	-40.93
	GulfB+SAtlB+BFT	-3.79	-17.72	19.79	28.92	17.71	-35.08	9.09	-40.45
	GulfC+SAtlC+BFT	4.51	21.97	16.79	90.78	12.21	-41.48	-8.92	-40.11
	GulfC+SAtlA+BFT	5.76	23.04	21.50	94.65	12.63	-42.01	-8.68	-41.59
	GulfC+SAtlB+BFT	8.6	23.62	27.41	101.92	17.10	-44.50	-8.77	-41.11
95-97	GulfA+SAtlC+BFT	-6.02	-23.92	9.70	-11.70	13.57	-47.81	8.42	-38.45
	GulfA+SAtlA+BFT	-4.24	-22.48	12.74	-8.36	13.77	-48.01	8.53	-38.96
	GulfA+SAtlB+BFT	0.52	-20.98	19.47	-1.94	16.44	-47.33	4.89	-39.85
	GulfB+SAtlC+BFT	-5.83	-22.68	4.96	-9.50	6.29	-47.76	8.06	-34.48
	GulfB+SAtlA+BFT	-4.05	-21.24	8.00	-6.16	6.48	-47.96	8.18	-36.00
	GulfB+SAtlB+BFT	0.72	-19.74	14.73	0.26	9.17	-47.29	4.53	-36.89
	GulfC+SAtlC+BFT	5.53	9.07	5.99	37.84	10.97	-49.45	-7.43	-27.50

Year	Closed Areas	Swords Kept	Swords Discard	BUM Discard	SAI Discard	WHM Discard	BFT Discard	BAYS Kept	Mahi Kept
	GulfC+SAtlA+BFT	7.32	10.51	9.03	41.18	11.16	-49.64	-7.32	-28.01
	GulfC+SAtlB+BFT	12.08	12.01	15.77	47.60	13.83	-48.97	-10.96	-28.91

Table 11. Number of blue marlin, white marlin and sailfish discarded, by area, from U.S. commercial longline vessels, based on pelagic logbook reports (Cramer, 1999)

Area	White Marlin			Blue Marlin			Sailfish		
	95	96	97	95	96	97	95	96	97
CAR	272	171	153	699	463	292	89	44	40
GOM	645	919	359	553	848	497	666	566	600
FEC	120	109	96	134	203	171	159	304	191
SAB	191	287	140	262	386	154	164	248	121
MAB	834	275	269	166	50	38	18	20	3
NEC	363	408	416	63	252	53	1	10	0
NED	22	12	8	16	3	3	0	0	1
SAR	3	33	5	4	6	1	1	2	0
NCA	338	161	89	385	135	69	42	21	7
TUN	378	422	251	594	824	605	97	188	222
TUS	0	35	505	21	122	353	1	39	495
Total	3166	2832	2291	2897	3292	2236	1238	1442	1680

Table 12. Calculation procedures for estimating Atlantic billfish discards from Caribbean and Southwest Atlantic Ocean areas by U.S. pelagic longline fishermen.

Species	Year	Total Dead Discards from Pelagic LL (mt) **A**	Discards from Caribbean & SW Atlantic (mt) **B**	Percent Discards **NON**-Caribbean/SW Atlantic **(A-B)/A*100**
Blue Marlin	1995	143.8	89.4	37.8
	1996	196.5	125.9	35.9
	1997	138.1	66.1	52.1
White Marlin	1995	99.7	30.6	69.3
	1996	67.6	26.8	60.4
	1997	70.8	44.2	37.6
Sailfish	1995	28.7	5.6	80.5
	1996	71.6	10.3	85.6
	1997	57.7	35.2	39.0

Table 13. Cumulative impact of closures of areas in Gulf (March through September) and SE U.S. Atlantic coast on billfish species with displacement without Caribbean and SW Atlantic catches for 1995 to 1997.

Closed Areas	BUM Discard	SAI Discard	WHM Discard
GulfA+SAtlC+BFT	-6.26	-16.2	6.76
GulfA+SAtlA+BFT	-6.46	-13.85	5.56
GulfA+SAtlB+BFT	-5.44	-9.27	5.51
GulfB+SAtlC+BFT	-11.00	-14.00	-0.51

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Closed Areas	BUM Discard	SAI Discard	WHM Discard
GulfB+SAtlA+BFT	-11.20	-11.64	-1.71
GulfB+SAtlB+BFT	-10.18	-7.07	-1.77
GulfC+SAtlC+BFT	-9.96	33.33	4.16
GulfC+SAtlA+BFT	-10.17	35.70	2.96
GulfC+SAtlB+BFT	-9.14	40.26	2.90

Table 14. Closure effectiveness of selected options under the time/area alternative, 1995 to 1997.

	Portion of Catch Attempting to Reduce									Minimize Impacts on this Portion of Catch			
Area	Swd discard	BUM discard	WHM discard	SAI discard	BFT discard	Turtles caught	Pelagic sharks discard	LCS discard	Mahi mahi kept	Swd kept	BAYS kept	Pelagic sharks kept	LCS kept
No Displacement Model													
GulfB+ SAtlC+BFT	-41.9	-24.7	-21.6	-42.5	-60.3	-4.1	-4.8	-49.7	-61.1	-25.6	-19.4	-13.3	-37.7
GulfB+ SAtlB+BFT	-45.4	-26.7	-28.5	-43.3	-64.4	-6.3	-11.4	-66.0	-66.8	-27.6	-30.6	-37.4	-66.5
GulfC+ SAtlB+BFT	-49.6	-29.8	-32.9	-55.3	-65.2	-7.0	-11.6	-72.7	-78.4	-29.5	-38.5	-39.3	-72.8
Displacement Model													
GulfB+ SAtlC+BFT	-22.7	-11.0*	-0.5*	-14.0*	-47.8	9.2	11.1	-27.6	-35.5	-5.8	8.1	9.0	-16.1
GulfB+ SAtlB+BFT	-19.7	-10.2*	-1.8*	-7.1*	-47.2	16.2	12.9	-42.4	-36.9	0.7	4.5	-13.3	-49.1
GulfC+ SAtlB+BFT	12.0 (-29.4)	-9.1* (-18.4)	2.9* (-12.2)	40.3* (-31.6)	-49.0 (-49.3)	15 (14.5)	12.9 (12.6)	-4.0 (-56.9)	-28.9 (-59.6)	12.1 (-3.9)	-11.0 (-13.1)	-6.3 (-17.3)	35.4 (-60.1)

Note: values in parenthesis for options including GulfC displacement indicate the percent change if no displacement values are substituted for the GulfC displacement values due to the "skewed" results for the displacement model in this area for some species.
* percent changes for billfish under the displacement model the the "adjusted" values explained in the text in relation to the probability of effort moving into the Caribbean and southwestern Atlantic.

Figure 16. Percent change in total bycatch, by species, by month during 1995 from closures in the Gulf of Mexico.

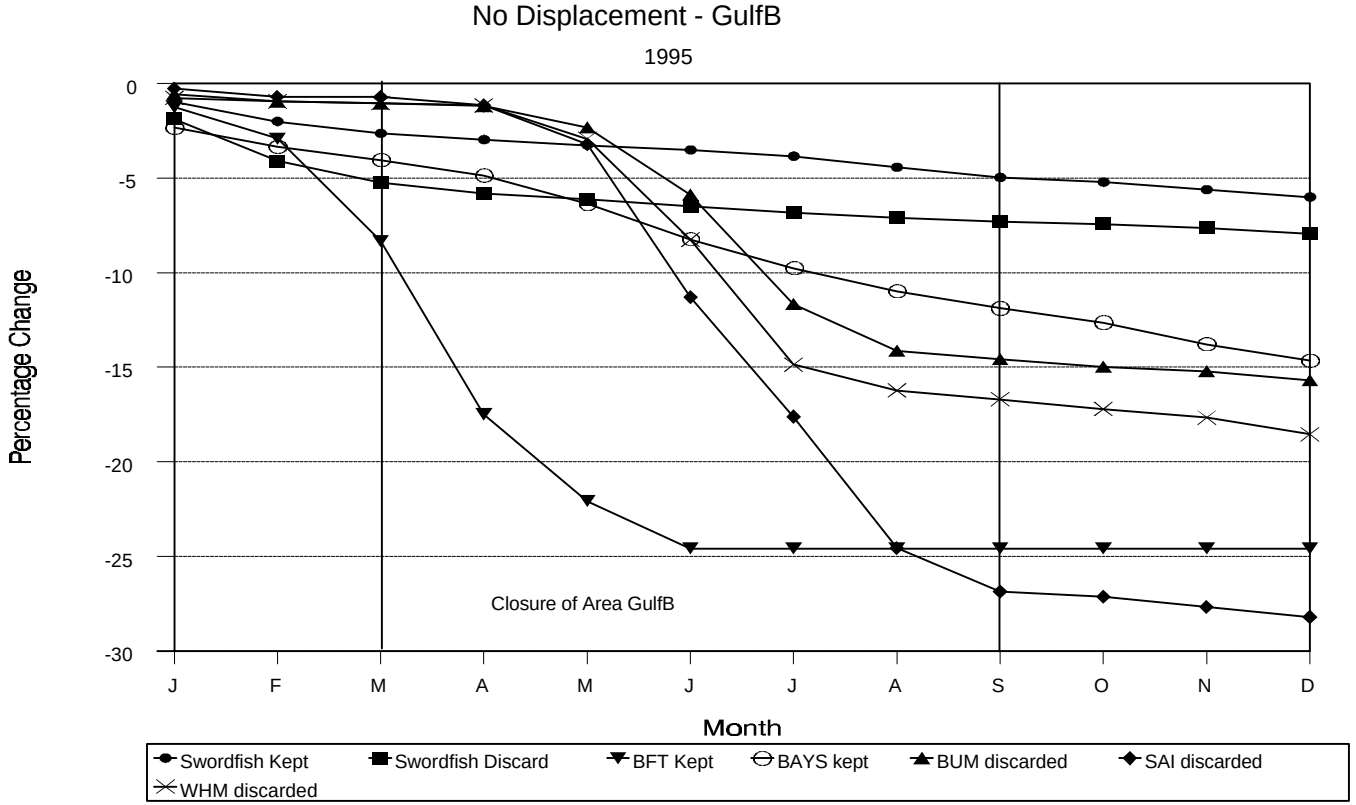
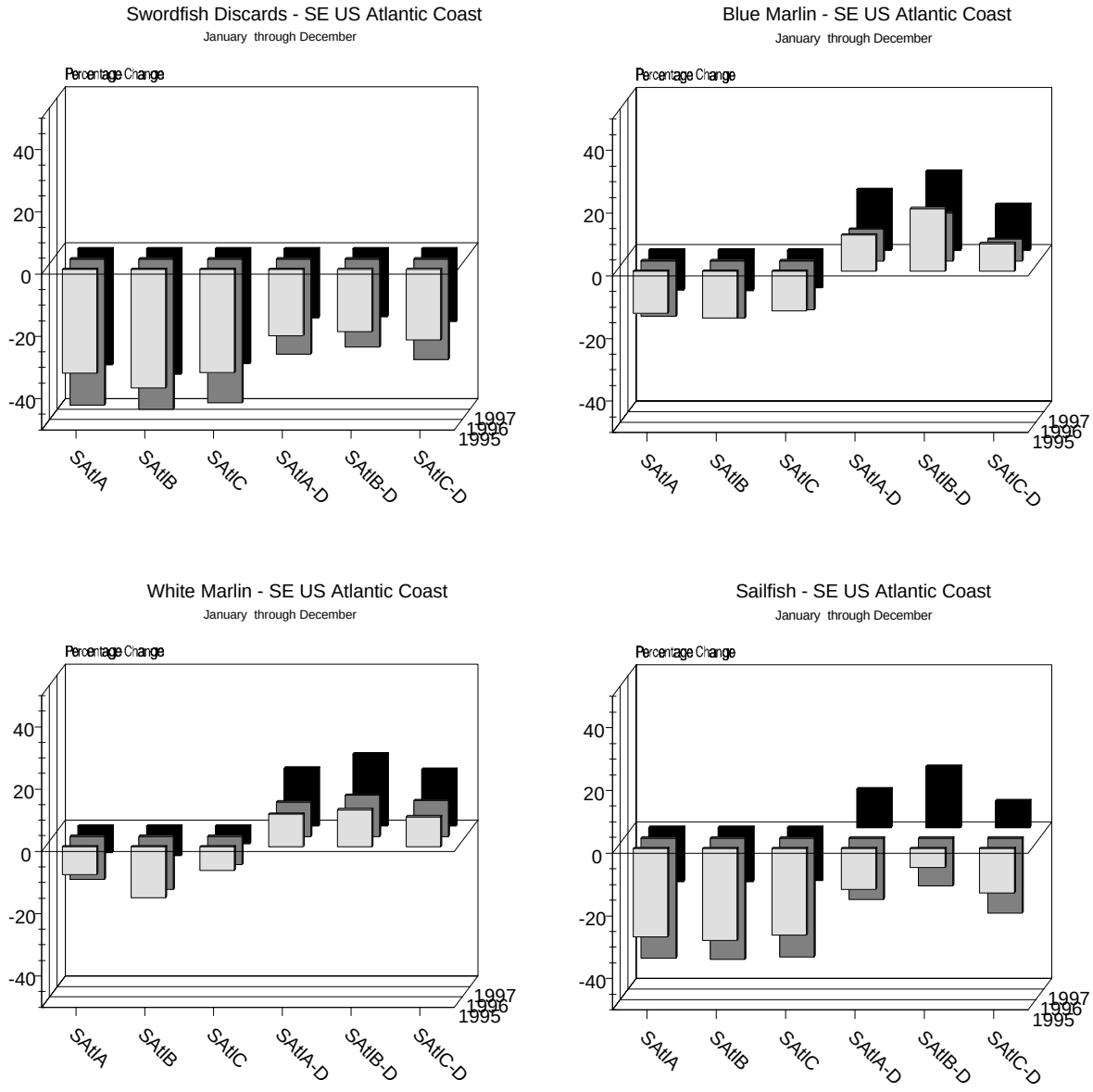
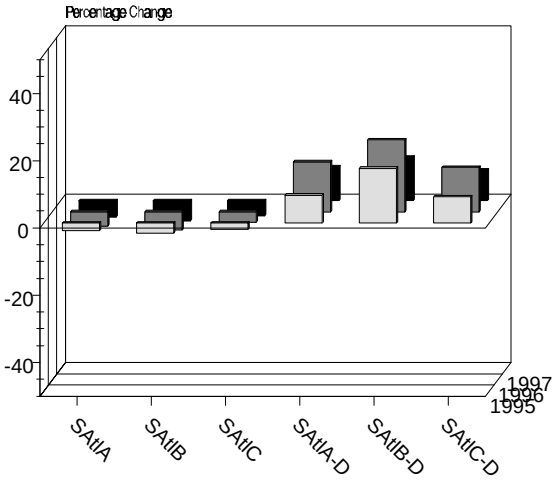


Figure 17. Percent change in catch and discards from pelagic longline closures along the SE U.S. Atlantic coast.



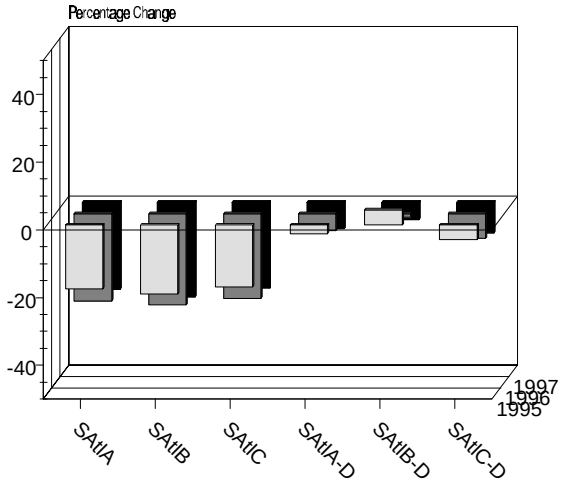
Sea Turtles - SE US Atlantic Coast

January through December



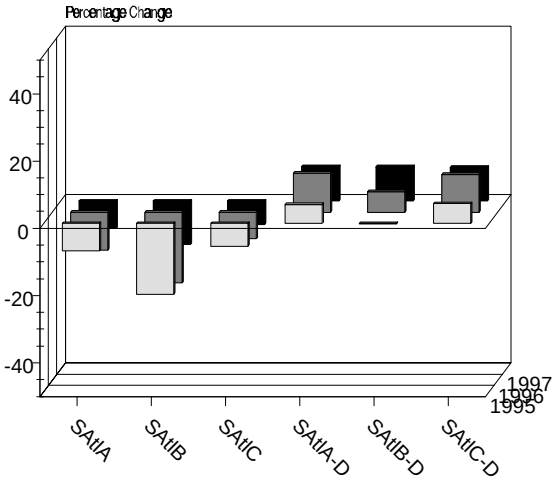
Swordfish Kept - SE US Atlantic Coast

January through December



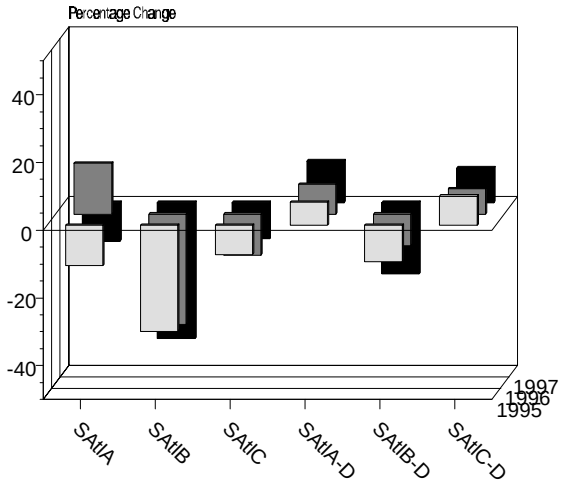
BAYS Kept - SE US Atlantic Coast

January through December



Pelagic Sharks Kept - SE US Atlantic Coast

January through December



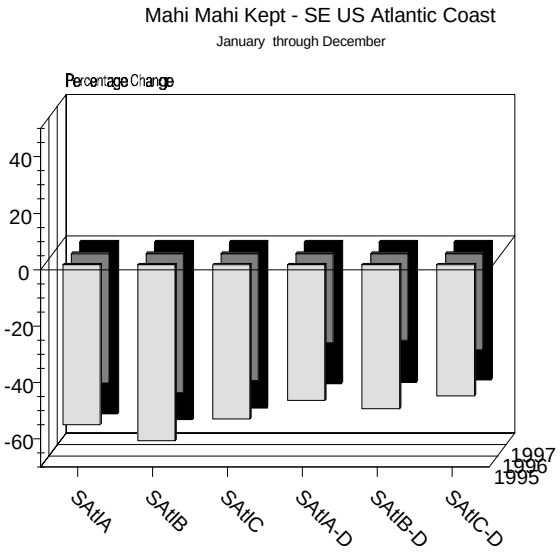

Mahi Mahi Kept - SE US Atlantic Coast
January through December
Percentage Change
40
20
0
-20
-40
-60
1997
1996
1995
SAtlA
SAtlB
SAtlC
SAtlA-D
SAtlB-D
SAtlC-D

Figure 18. Distribution of pelagic longline vessels, by horsepower, reporting catches within the spatial constraints of the various time-area scenarios.

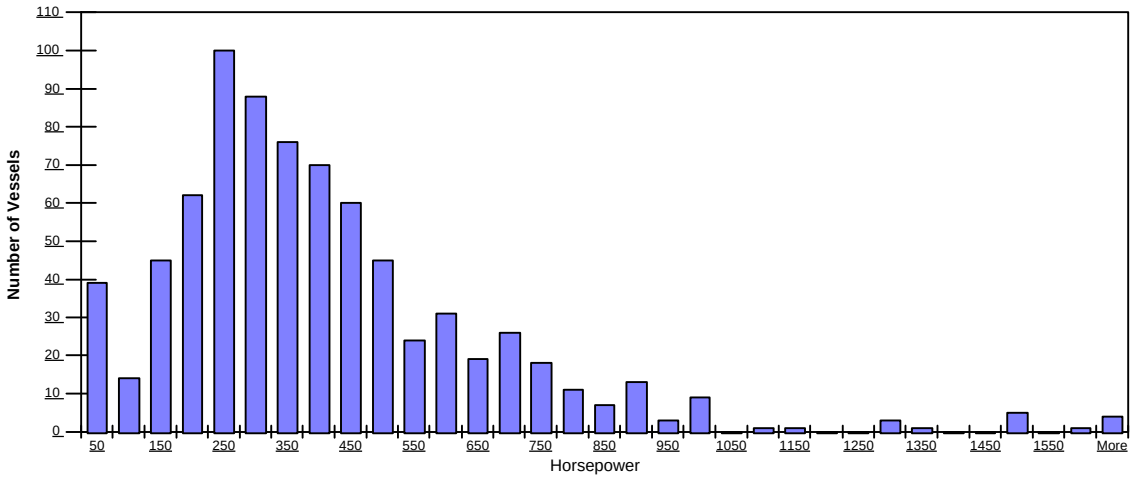


Figure 19. Distribution of pelagic longline vessels, by vessel length, reporting catches within the spatial constraints of the various time-area scenarios.

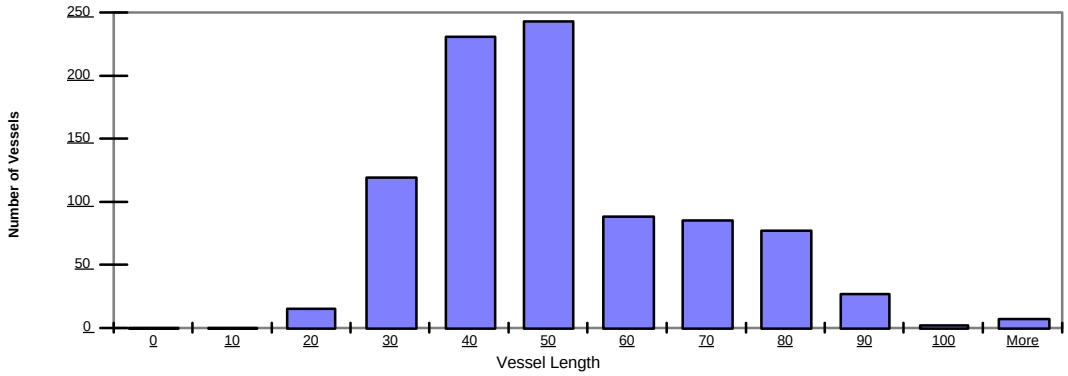


Figure 20. Distribution of pelagic longline vessels, by homeport state, reporting catches within the spatial constraints of the various time-area scenarios.

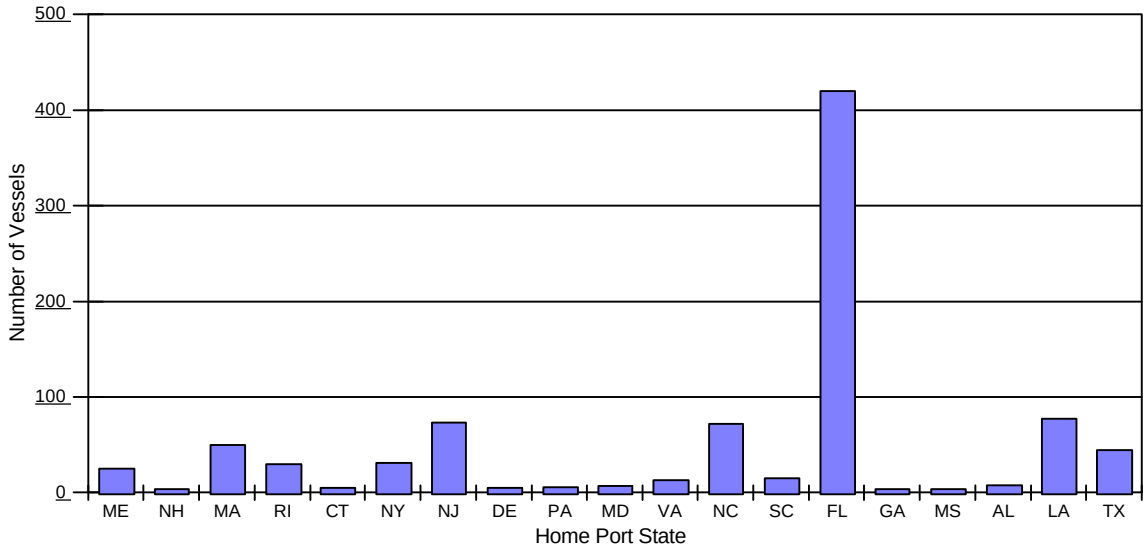
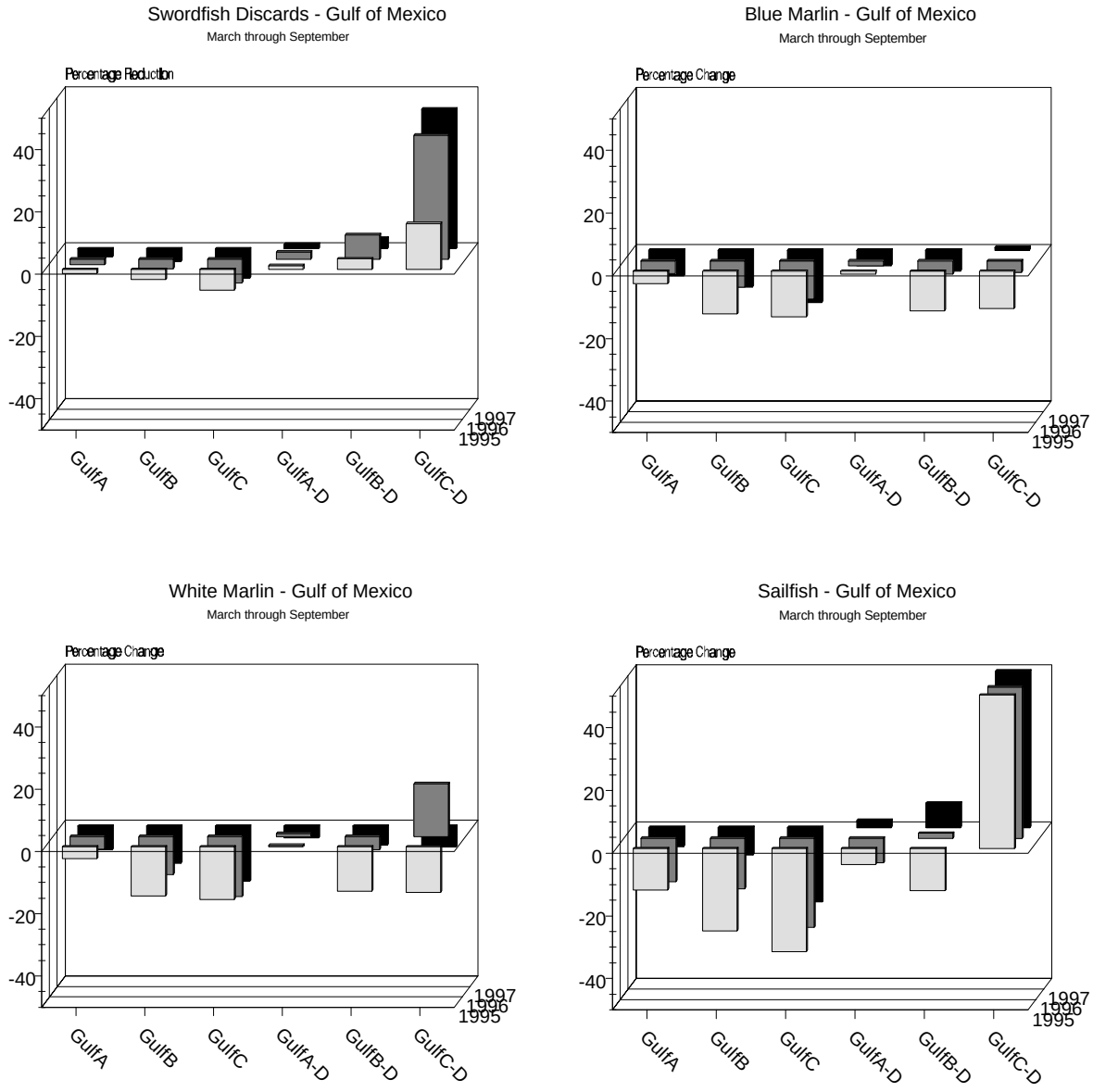
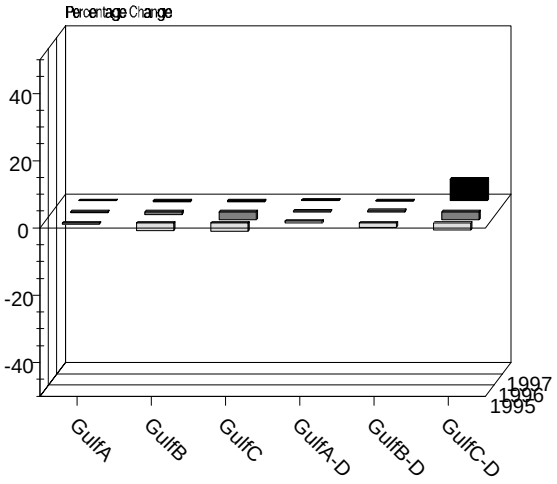


Figure 21. Percent change in catch and discards from pelagic longline closures in the Gulf of Mexico.



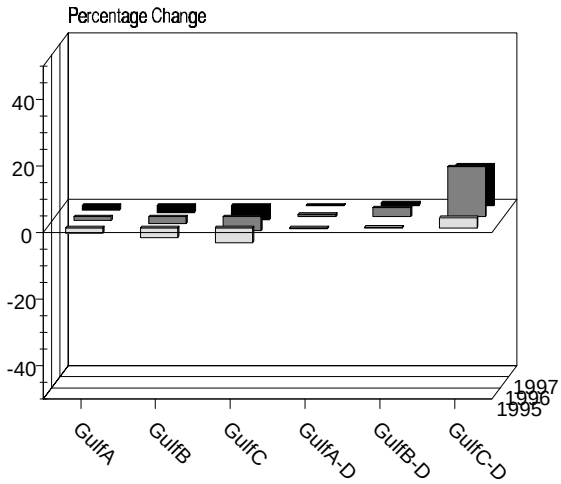
Sea Turtles - Gulf of Mexico

March through September



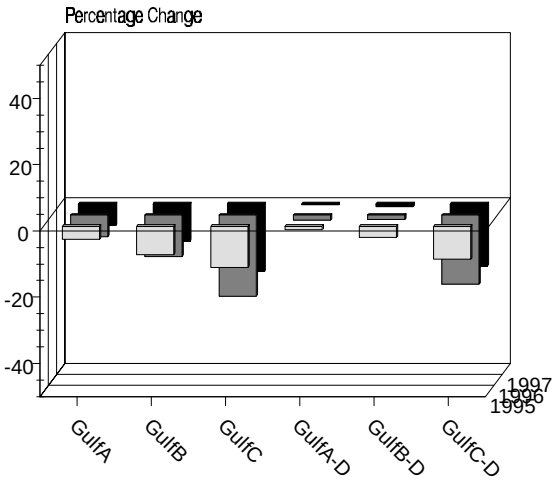
Swordfish Kept - Gulf of Mexico

March through September



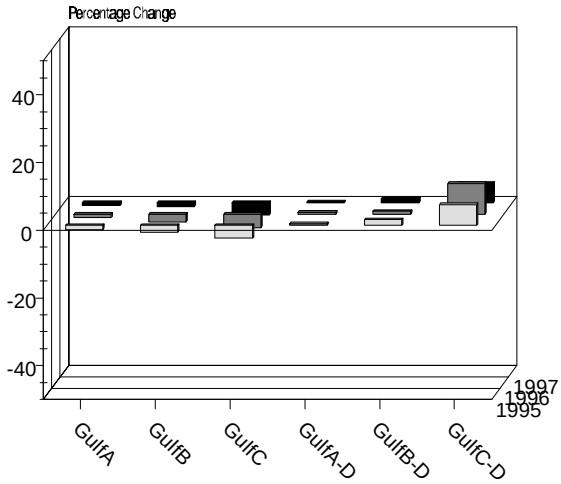
BAYS Kept - Gulf of Mexico

March through September



Pelagic Sharks Kept - Gulf of Mexico

March through September



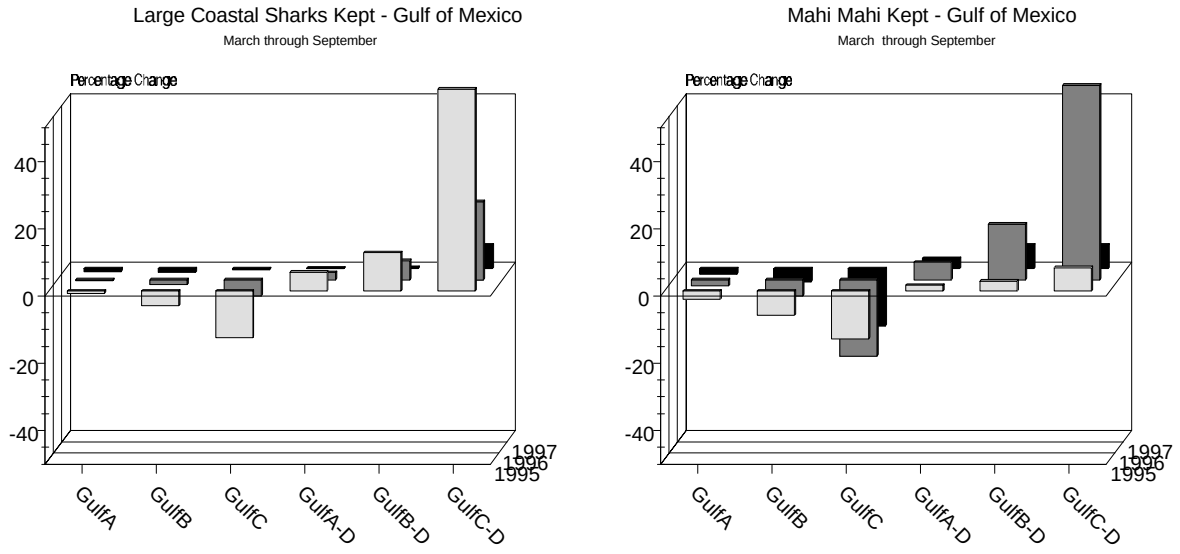


Figure 22. Percent change in bycatch, and incidental and target catch resulting from closure of area GulfB (March through September), SAtlC (year-round), and the bluefin tuna closure (June), 1995 to 1997.

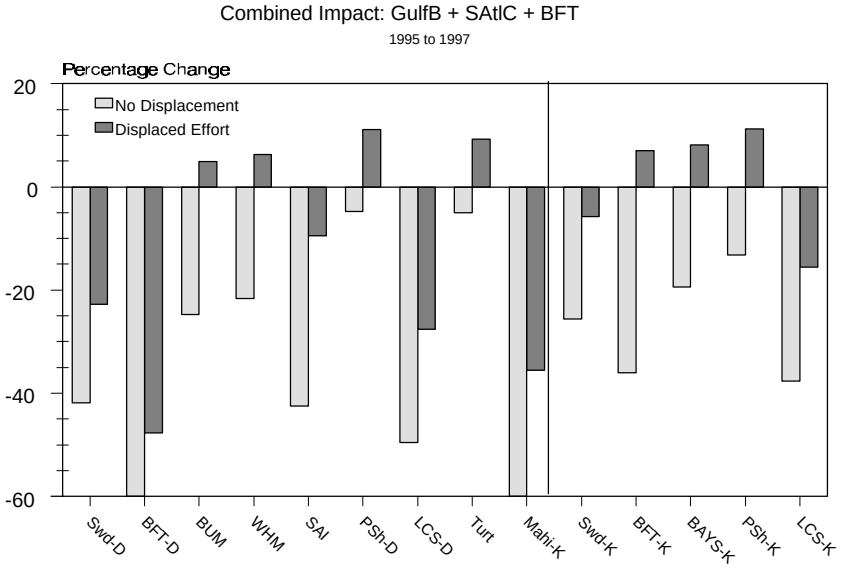


Figure 23. Percent change in bycatch, and incidental and target catch resulting from closure of area GulfB (March through September), SAtlB (year-round), and the bluefin tuna closure (June), 1995 to 1997.

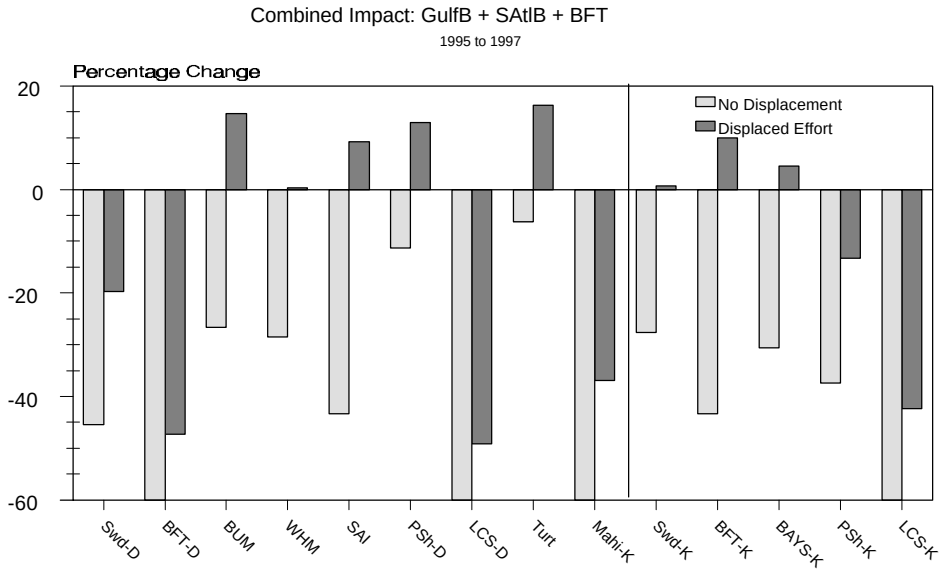


Figure 24. Percent change in bycatch, and incidental and target catch resulting from closure of area GulfC (March through September), SAtlB (year-round), and the bluefin tuna closure (June), 1995 to 1997.